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(54) TWO-SUBSTANCE NOZZLE AND METHOD FOR SPRAYING A LIQUID-GAS MIXTURE

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B05B 1/34 (2006.01)

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CPC . ***B05B 7/10*** (2013.01); ***B05B 1/341*** (2013.01); ***B05B 1/3405*** (2013.01)

(58) **Field of Classification Search**
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USPC 239/399, 400, 419–419.5, 426–428, 239/432, 433, 434, 463, 469, 474, 475, 482, 239/483, 484, 485, 487, 488, 490, 491–497
See application file for complete search history.

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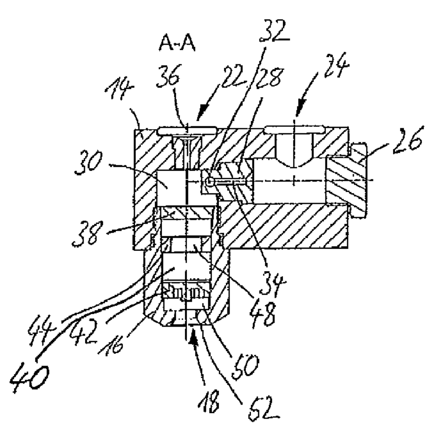
(57) ABSTRACT

A two-substance nozzle for spraying a liquid-gas mixture, including a nozzle housing including at least one liquid inlet leading into a mixing chamber and at least one gas inlet leading into the mixing chamber, a swirl insert, an outlet chamber between the swirl insert and an outlet opening on the downstream end of the outlet chamber, wherein a restrictor is provided on the downstream end of the mixing chamber and an intermediate chamber is provided between the restrictor and the swirl insert.

11 Claims, 7 Drawing Sheets



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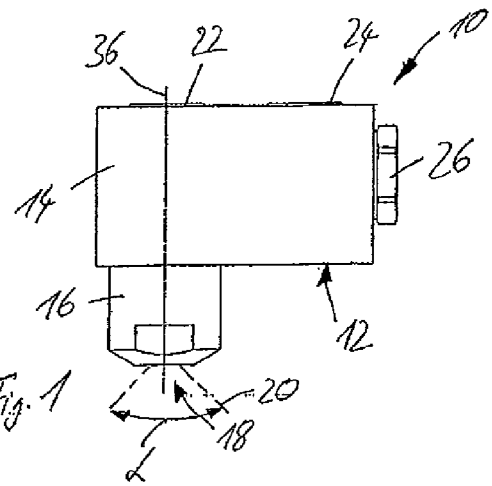

Fig. 1

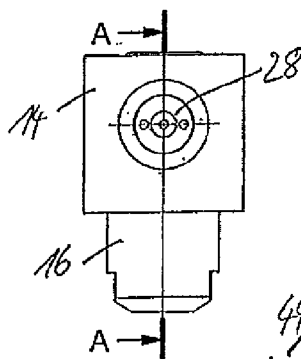

Fig. 2

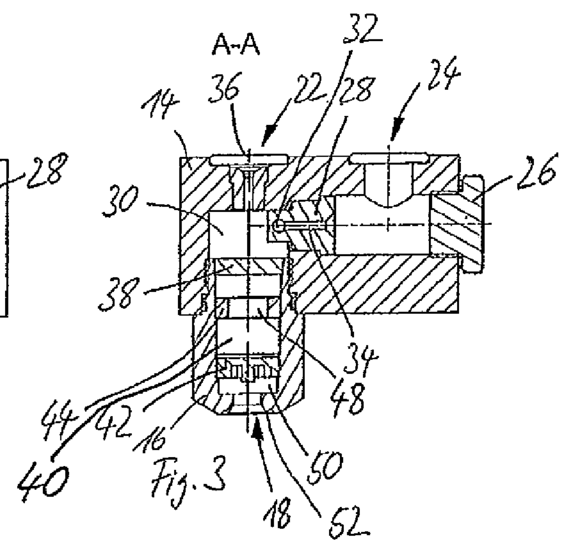

Fig. 3

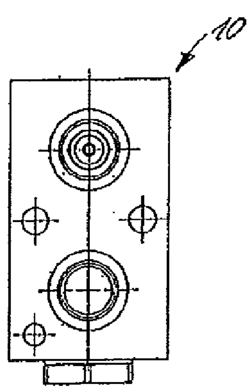

Fig. 4

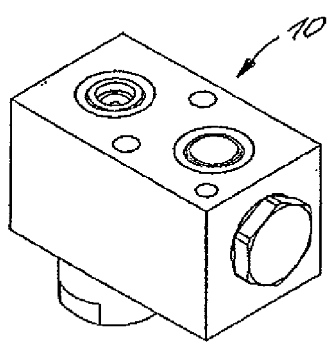

Fig. 5

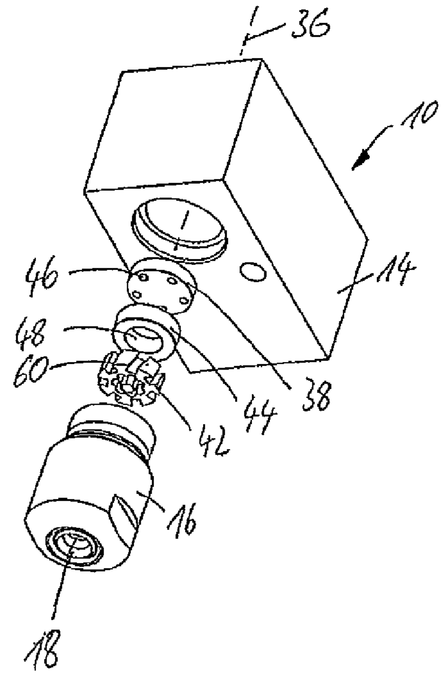

Fig. 6

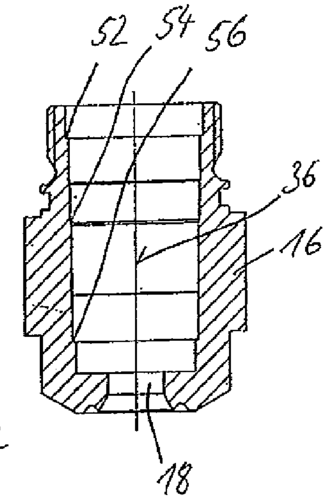

Fig. 7

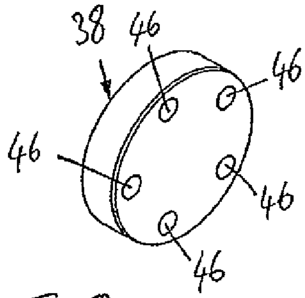

Fig. 8

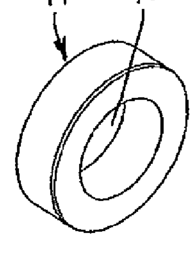

Fig. 9

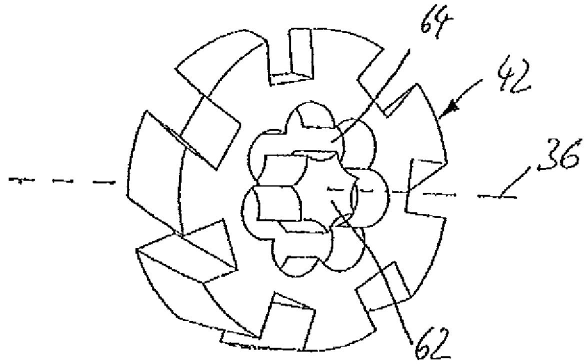

Fig. 10

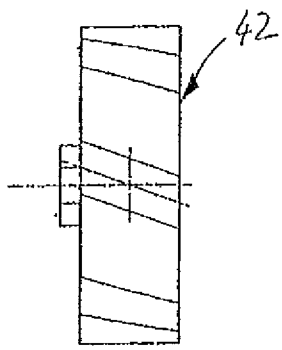

Fig. 11

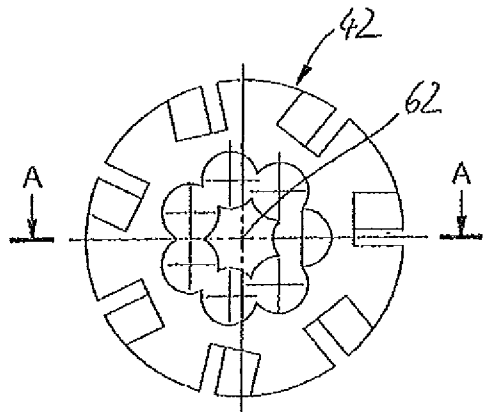

Fig. 12

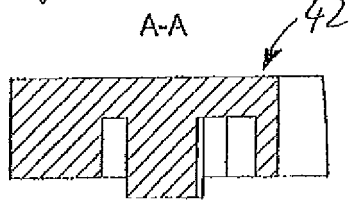

Fig. 13

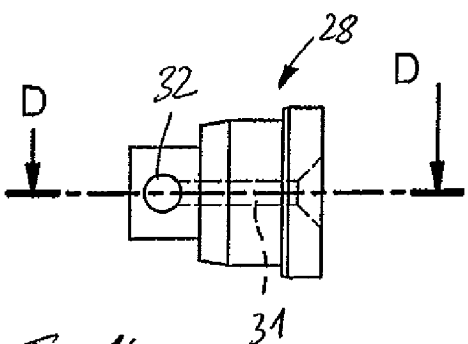

Fig. 14

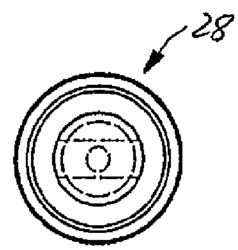

Fig. 15

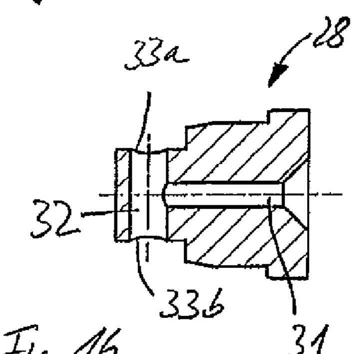

Fig. 16

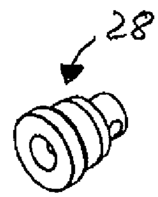

Fig. 17

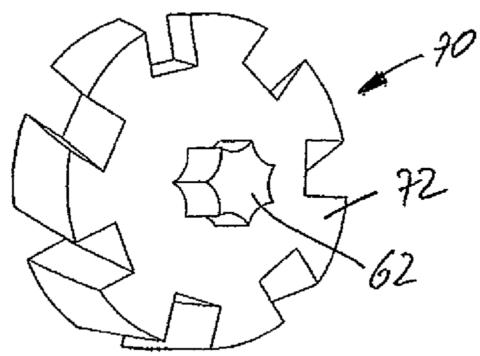

Fig. 18

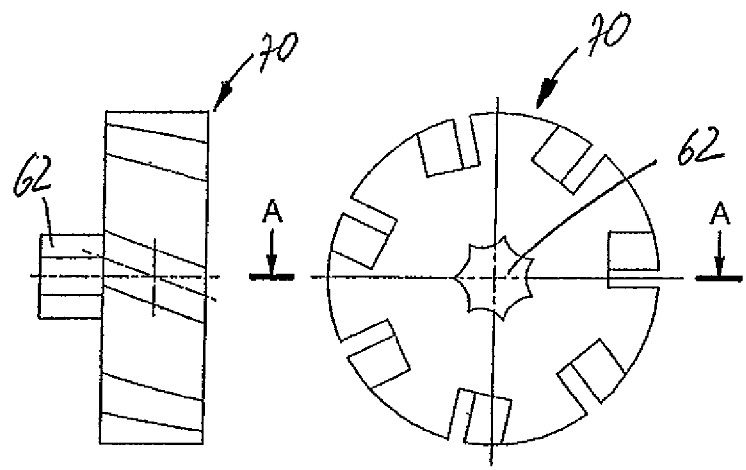

Fig. 19 Fig. 20

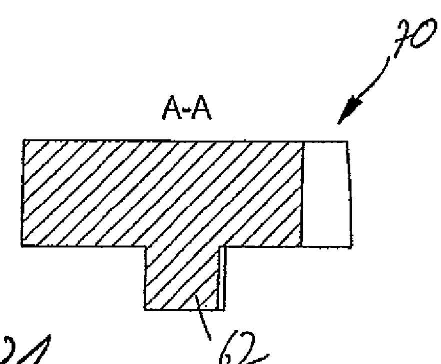

Fig. 21

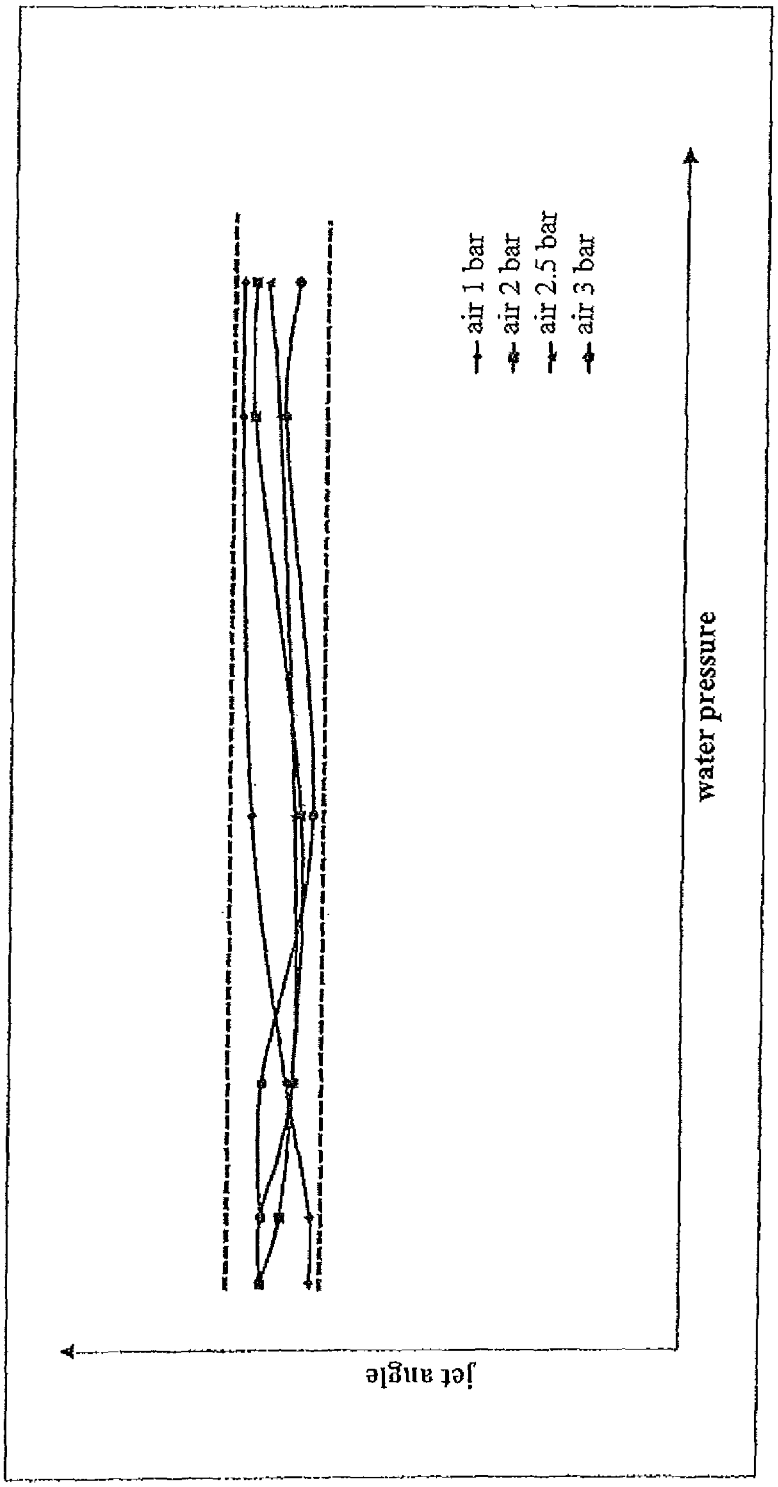
air 1 bar
air 2 bar
air 2.5 bar
air 3 bar
water pressure
jet angle

Fig. 22

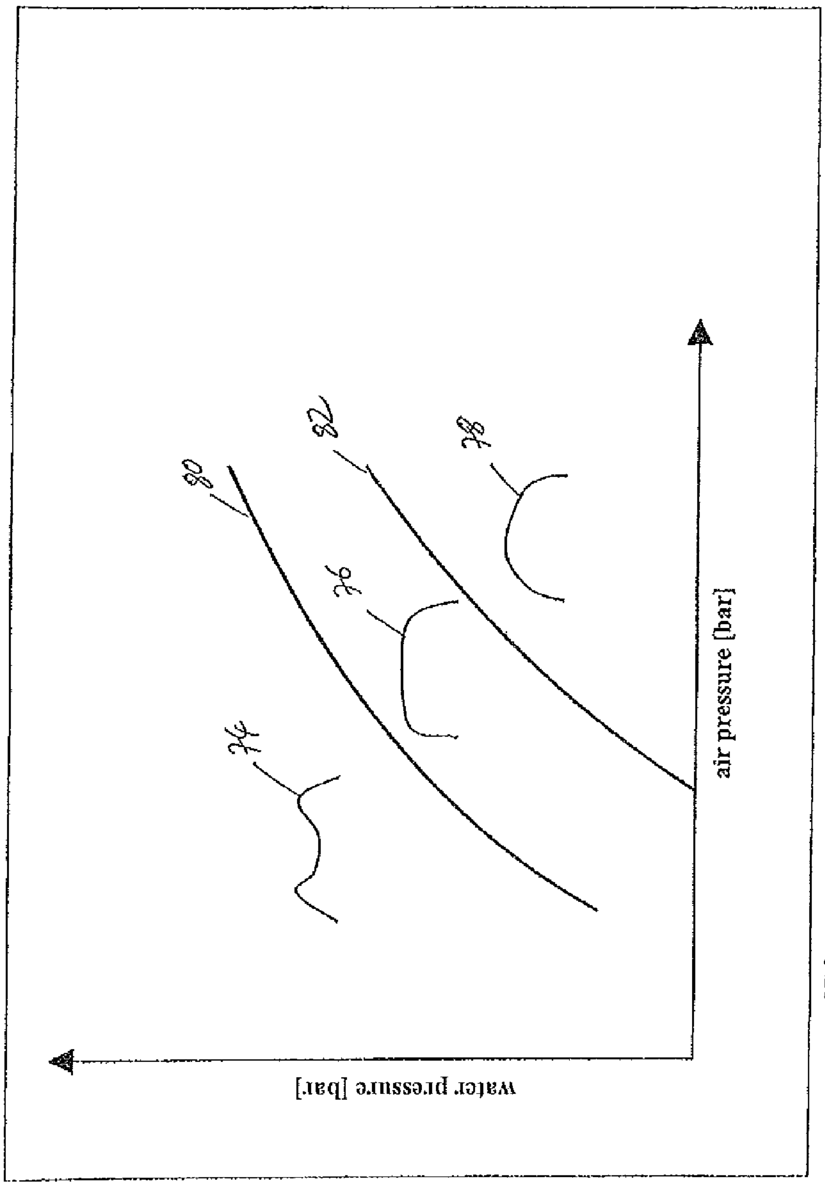

Fig. 23

TWO-SUBSTANCE NOZZLE AND METHOD FOR SPRAYING A LIQUID-GAS MIXTURE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority of German Application No. 10 2013 203 339.7, filed on Feb. 28, 2013, the disclosure of which is hereby incorporated by reference in its entirety into this application.

FIELD AND BACKGROUND OF THE INVENTION

The invention relates to a two-substance nozzle for spraying a liquid-gas mixture, comprising a nozzle housing including at least one liquid inlet leading into a mixing chamber and at least one gas inlet leading into the mixing chamber, a swirl insert and an outlet chamber between the swirl insert and an outlet opening on the downstream end of the outlet chamber. The invention also relates to a method for spraying a liquid-gas mixture.

SUMMARY OF THE INVENTION

The object of the invention is to provide an improved two-substance nozzle and an improved method for spraying a liquid-gas mixture.

What is provided according to the invention is a two-substance nozzle for spraying a liquid-gas mixture, comprising a nozzle housing including at least one liquid inlet leading into a mixing chamber and including at least one gas inlet leading into the mixing chamber, including a swirl insert, and including an outlet chamber between the swirl insert and an outlet opening on the downstream end of the outlet chamber, with a restrictor on the downstream end of the mixing chamber and an intermediate chamber between the restrictor and the swirl insert being provided.

Surprisingly, providing a restrictor on the downstream end of the mixing chamber and providing an intermediate chamber upstream of the swirl insert allows implementation of a two-substance nozzle which has an essentially constant jet angle of the spray jet output via the outlet opening. Said essentially constant jet angle is maintained during variation of a pressure of the supplied gas and/or a pressure of the supplied liquid. Thereby, the two-substance nozzle according to the invention is capable of providing an essentially constant jet angle during variable or unsteady water pressure, for example. This is particularly important, for example, in case the two-substance nozzle according to the invention is employed for cooling of strands in continuous casting units for long products. The main requirement with secondary cooling in continuous casting units is to effect a controlled, uniform cooling. Such a cooling is performed by means of two-substance spray nozzles. The cooling is to cause solidification of a defect-free casting strand, that is, a flawless strand generally free of cracks and segregations. For example, so-called billets, cogged ingots or round format ingots are produced in continuous casting units and cooled using two-substance nozzles. Due to the numerous different steel qualities and the differing characteristics thereof, and due to the large scope of casting rates, there is need to provide a large nozzle control range for such two-substance nozzles. This means that on the one hand, very major cooling with high volume flow and on the other hand, very gentle cooling with low volume flow should be feasible. If upon a variation of the volume flow and, for example, upon a variation of the water

pressure, the jet angle of the two-substance spray nozzles in the secondary cooling would vary as well, then the result thereof could be defects in the produced strands, due to insufficient cooling over the total exterior surface thereof, for example. The two-substance spray nozzle according to the invention overcomes this problem, since even with variable or unsteady water pressures, the jet angle of the output spray jet remains essentially constant. As a result of the varying liquid pressure and/or the varying gas pressure, there is merely a variation in the volume distribution within the spray jet occurring, that is, the distribution of the liquid in the output spray jet. This property can be used intentionally to adjust, by means of variation of the liquid pressure and/or the water pressure, a defined different liquid distribution in the spray jet and thus a different cooling of the cast strand treated thereby. Surprisingly, an essentially constant jet angle can be obtained by means of providing a restrictor on the downstream end of the mixing chamber and of an intermediate chamber between the restrictor and the swirl insert, in a very simple manner. Downstream of the restrictor is a uniform distribution of liquid and gas in the liquid-gas mixture, and segregation is prevented. Due to the restrictor, there is a significant reduction in the pressure dependence of the jet angle observed. The intermediate chamber is dimensioned such that there is no segregation occurring between the restrictor and the swirl insert. By means of the swirl insert, the liquid-gas mixture can be caused to rotate, and downstream of the outlet opening a full cone or a hollow cone may be produced, for example.

In an advanced embodiment of the invention, the restrictor includes a perforated plate.

By means of a perforated plate, a restrictor for the liquid-gas mixture in the mixing chamber can be provided in a very simple manner.

In an advanced embodiment of the invention, the perforated plate exclusively has a plurality of through-holes disposed in the vicinity of the plate periphery.

It was observed that a plurality of through-holes provided exclusively in the vicinity of the periphery of the perforated plate cause a very uniform liquid-gas distribution in the intermediate chamber, and thus the desired independence of the jet angle from liquid pressure and gas pressure is obtained. Therein, the through-holes may be bores disposed at a distance to the periphery, or may even be grooves provided on the periphery of the perforated plate, for example.

In an advanced embodiment of the invention, the restrictor has an orifice including one single, central through-hole.

Such a restrictor can cause a very advantageous liquid-gas distribution in the intermediate chamber, in particular together with a perforated plate.

In an advanced embodiment of the invention, as viewed in the flow direction, the perforated plate is located upstream of the orifice. Advantageously, the orifice is spaced from the perforated plate, as viewed in the flow direction.

As viewed in the flow direction, the orifice may be at a distance to the perforated plate of approximately the radius of the perforated plate. The size of the central through-hole in the orifice is advantageously selected such that the through-hole has a diameter that is smaller than the distance between the through-holes in the perforated plate. In other words, in a projection, the through-holes are completely covered by the orifice.

In an advanced embodiment of the invention, the swirl insert has a plurality of bores or grooves disposed in the peripheral zone or on the outer circumference, wherein the bores or grooves are extending obliquely or helically relative to a central longitudinal axis of the outlet chamber.

In an advanced embodiment of the invention, the swirl insert has a stud protruding into the flow direction and located in the central zone on the downstream side of the insert.

By providing such a stud, the spray characteristic of the two-substance nozzle according to the invention can be varied. Providing such a stud causes generation of a full cone spray jet. With no stud provided on the swirl insert, a hollow cone spray jet is generated. Therein, the stud on the swirl insert is facing the outlet chamber, thus extends in the flow direction. Liquid distribution within the spray jet can be adjusted by the length of the stud. The longer the stud is extended, the more liquid is directed in the center of the jet.

In an advanced embodiment of the invention, the outer circumference of the stud has a non-circular shape.

In an advanced embodiment of the invention, the stud is surrounded by a groove, at least in the vicinity of its end starting from the swirl insert. The groove is annular therein, but advantageously has a non-circular circumference. For example, the groove can be composed of a plurality of adjacent blind holes disposed on a circle. Thus, the blind holes define both the outer circumference of the stud and the outer circumference of the groove.

In an advanced embodiment of the invention, the mixing chamber has a central longitudinal axis, and the at least one liquid inlet leads into the mixing chamber in general tangentially to an imaginary circle around the central longitudinal axis.

By means of tangential feeding of the liquid into the mixing chamber, a very uniform admixing of liquid and gas is achieved already in the mixing chamber. As used herein, the term in general tangentially is to mean perpendicular to the central longitudinal axis, however, not directed in the direction of the restrictor on the downstream end of the mixing chamber, and also not in the opposite direction. Consequently, due to the liquid inlet ending in a generally tangential orientation, the liquid is introduced relative to the central longitudinal axis of the mixing chamber such that the liquid is introduced with a spin around the central longitudinal axis. Thus, the liquid can also be introduced into the mixing chamber obliquely to the tangential direction, that is, obliquely offset in the direction of the central longitudinal axis.

In an advanced embodiment of the invention, at least two liquid inlets are provided, each leading into the mixing chamber in general tangentially to an imaginary circle around the central longitudinal axis, but in opposed directions relative to one another.

In this manner, admixing of liquid and gas in the mixing chamber is further improved.

The object of the invention is also achieved by a method for spraying a liquid-gas mixture using a two-substance nozzle, wherein in a mixing chamber including at least one liquid inlet and at least one gas inlet the liquid-gas mixture is produced, and wherein by means of a swirl insert the liquid-gas mixture is caused to rotate around a central longitudinal axis and is output through an outlet opening, wherein conducting the liquid-gas mixture is provided via a restrictor on the downstream end of the mixing chamber, and conducting the liquid-gas mixture is provided through an intermediate chamber between the restrictor and the swirl insert.

In an advanced embodiment of the invention, variation of a distribution of the liquid-gas mixture in an output spray cone by means of varying a pressure of the gas and/or the liquid is provided, wherein a spray angle of the output spray cone remains essentially constant during a variation of the pressure of the gas and/or the liquid.

In this manner, a distribution of the liquid-gas mixture in the output spray cone can be affected selectively and deliberately, for example, to allow defined variation of a differential cooling of a strand sprayed using the two-substance spray nozzle.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages of the invention will become apparent from the claims and the following description of preferred embodiments of the invention together with the drawings. Individual features illustrated in the various figures of the drawings may be combined in any arbitrary combination without departing from the scope of the invention.

FIG. **1** a side elevation view of a two-substance nozzle according to the invention;

FIG. **2** a side elevation view of the two-substance nozzle of FIG. **1**, wherein a locking screw, illustrated on the right hand side in FIG. **1**, is removed;

FIG. **3** a view on sectional plane A-A of FIG. **2**;

FIG. **4** a top view on the two-substance nozzle of FIG. **1**;

FIG. **5** an oblique view from above on the two-substance nozzle of FIG. **1**;

FIG. **6** an expanded illustration of the two-substance nozzle of FIG. **1**;

FIG. **7** a sectional view of a short pipe of the two-substance nozzle of FIG. **1**;

FIG. **8** an oblique view from above on a perforated plate of the two-substance nozzle of FIG. **1**;

FIG. **9** an oblique view from above on an orifice of the two-substance nozzle of FIG. **1**;

FIG. **10** an oblique view from above on a swirl insert of the two-substance nozzle of FIG. **1**;

FIG. **11** a side elevation view of the swirl insert of FIG. **10**;

FIG. **12** a top view on the swirl insert of FIG. **10**;

FIG. **13** a sectional view on the sectional plane A-A of FIG. **12**;

FIG. **14** a side elevation view of a liquid inlet part of the two-substance nozzle of FIG. **1**;

FIG. **15** a front view of the liquid inlet part of FIG. **14**;

FIG. **16** a view on the sectional plane D-D;

FIG. **17** an oblique view from above on the liquid inlet part of FIG. **14**;

FIG. **18** an oblique front view of a swirl insert for a two-substance nozzle according to the invention in a second embodiment;

FIG. **19** a side elevation view of the swirl insert of FIG. **18**;

FIG. **20** a front view of the swirl insert of FIG. **18**;

FIG. **21** a view on the sectional plane A-A in FIG. **20**;

FIG. **22** an illustration of the variation of the jet angle of the two-substance nozzle according to the invention in FIG. **1** as a function of water pressure; and

FIG. **23** an illustration of the variation of the water distribution within the spray jet produced by the two-substance nozzle according to the invention in FIG. **1** as a function of water pressure and air pressure.

DETAILED DESCRIPTION

The illustration of FIG. **1** shows a two-substance nozzle **10** according to the invention comprising a nozzle housing **12**, wherein the nozzle housing **12** includes a first housing section **14** presenting an essentially rectangular shape, and a short pipe or mouthpiece **16** fixed to the first housing section. Within the mouthpiece **16** an outlet opening **18** (not visible in FIG. **1**) is provided to output a spray jet. The spray jet **20** has a cone shape, as illustrated in dashed lines in FIG. **1**. The spray jet has a jet angle α. A liquid connection **24** for supplying liquid to be sprayed, in particular water, and a pressurized gas connection **22** for supplying pressurized gas, in particular pressurized air, is provided on the first housing section **14**. A locking screw **26** is provided on the right hand side of the housing in FIG. **1**.

The illustration of FIG. **2** shows the two-substance nozzle of FIG. **1** in a side elevation view, wherein the locking screw **26** is not illustrated. Thus, a liquid inlet part **28** is visible within the first housing section **14**, and will be discussed in more detail with reference to FIG. **3** and FIGS. **14** to **17** hereinbelow.

The sectional view of FIG. **3** shows a top view on the sectional plane A-A of FIG. **2**. Pressurized gas is fed into the mixing chamber **30** via the pressurized gas connection **22**, where the mixing chamber is provided within the first housing section **14**. Water to be sprayed is fed into a cross hole of the first housing section **14** via the liquid connection **24** and then as well fed into the mixing chamber **30** via the liquid inlet part **28**. An end of the cross hole, located on the right hand side in FIG. **3**, is closed by a locking screw **26**. The liquid inlet part **28** has two aperture openings **33***a*, **33***b* for liquid, formed by means of a cross hole **32** in a stud protruding into the mixing chamber **30** of the liquid inlet part **28**. Said cross hole **32** is visible in the illustrations of FIG. **14** and FIG. **16**. Liquid enters into the liquid inlet part **28** via a longitudinal hole **31** to then impact onto the cross hole **32** in a perpendicular orientation. Thereby, the liquid is deflected within the liquid inlet part by 90° of angle, exits the liquid inlet part via the two aperture openings **33***a*, **33***b* of the cross hole **32**, and thus enters the mixing chamber **30** in an approximately tangential orientation. Therein, only the center of the cross hole **32** is strictly tangential, the ends of the cross hole issue outwards offset relative to the tangential direction of the aperture openings **33***a*, **33***b*. As is illustrated in FIG. **3**, the gas jet entering via the pressurized gas connection **22** and the liquid entering via the liquid inlet part **28** do not converge immediately. The liquid is introduced into the mixing chamber **30** through the cross hole **32** in general approximately tangentially in two opposed directions. The result thereof is proper and uniform admixing of liquid and gas within the mixing chamber **30**.

Starting from the mixing chamber **30**, the liquid-gas mixture is then transferred into an intermediate chamber **40** thereby passing a perforated plate **38**. The intermediate chamber **40** extends between the perforated plate **38** and a swirl insert **42**. An orifice **44** is disposed within the intermediate chamber. In the embodiment as illustrated, the perforated plate includes a total of five through-holes **46**, visible in the illustration of the perforated plate **38** in FIG. **8**. Therein, the through-holes **46** are arranged at uniform intervals one from the other on a circle that is concentric to the central longitudinal axis **36**. The through-holes **46** are disposed in the vicinity of a peripheral zone of the perforated plate **38**. The perforated plate **38** does not include any further perforations or passages in addition to the through-holes **46**. Thereby, the liquid from the mixing chamber **30** is enabled to enter the intermediate chamber **40** only via the through-holes **46**.

The orifice **44** includes but one through-hole **48** disposed concentric to the central longitudinal axis and designed in an annular shape. A diameter of the through-hole **48** in the orifice **44** is dimensioned such that in a projection along the central longitudinal axis **36**, the through-holes **46** in the perforated plate **38** are covered by the orifice **44**.

Thus, the liquid-gas mixture entering into the intermediate chamber **40** via the through-holes **46** of the perforated plate **38** is deflected by means of the orifice **44** and led in the through-hole **48** of the orifice **44**. The perforated plate **38** and the orifice **44** constitute a restrictor for the liquid-gas mixture.

Downstream of the orifice **44**, the diameter of the intermediate chamber **40** is again enlarging and the liquid-gas mixture is led up to the swirl insert **42**. By means of the swirl insert **42** the liquid-gas mixture is moved into a spin around the central longitudinal axis **36** and then enters an outlet chamber **50**, where an outlet opening **18** is disposed on the downstream end of said chamber. The outlet opening **18** has a cylindrical section starting from the outlet chamber **50** and a conical flaring section adjoining the cylindrical section, as viewed in the flow direction. The outlet opening **18** is provided in the short pipe or mouthpiece **16**, and concentrically surrounded by a drainage area or drop edge **52**.

The perforated plate **38** is provided on an end of the mouthpiece that is screwed into the first housing section **14**, and the orifice **44** and the swirl insert **42** are also disposed in the mouthpiece **16**. The mouthpiece **16**, cf. FIG. **7**, is provided with a plurality of steps, each matched to the diameter of the perforated plate **38**, the orifice **44** and the swirl insert **42**, respectively. Towards the direction of the outlet opening **18**, an inner diameter of the mouthpiece **16** becomes smaller. As viewed in the flow direction, the perforated plate **38** is disposed on a first circumferential step **52**. The orifice **44** is disposed on a second circumferential step **54**, and the swirl insert **42** is disposed on a third circumferential step **56**. Since the inner diameter of the mouthpiece **16** decreases from the first step **52** to the third step **56**, the swirl insert **42**, the orifice **44** and the perforated plate **38** can be inserted subsequently into the mouthpiece **16** without difficulties, and assume a defined position within the mouthpiece **16** due to the circumferential steps **56**, **54**, and **52**, respectively. There is an interior space of the mouthpiece **16** essentially in a cylindrical shape designed between the circumferential steps **52**, **54**, **56**. Therein, additional narrower circumferential steps can be provided, each on the level of a surface of the orifice **44** and the swirl insert **42** facing the flow.

The illustration of FIG. **4** shows a top view on the two-substance nozzle **10**, and FIG. **5** shows an oblique view from above on the two-substance nozzle **10**.

FIG. **6** shows the two-substance nozzle **10** in an expanded view. After inserting the swirl insert **42**, the orifice **44** and the perforated plate **38** into the short pipe **16**, said pipe is screwed into the first housing section **14**. FIG. **6** reveals that the liquid-gas mixture leaving the mixing chamber **30** at first and exclusively has to pass the through-holes **46** in the perforated plate **38**, and then is deflected into the central through-hole **48** of the orifice **44**. Downstream of the through-hole **48**, the liquid-gas mixture is again allowed to spread radially outwards, and then enters into the outlet chamber **50** via swirl ducts **60** on the outer circumference of the swirl insert **42**, to then be output via the outlet opening **18** as a spray cone. The swirl ducts **60** are arranged on the outer circumference of the swirl insert **42**, spaced at uniform intervals one from the other, and disposed obliquely to the central longitudinal axis **36**. Thereby, due to the swirl insert **42** the liquid-gas mixture is given a spin around the central longitudinal axis **36**, and as a consequence exits through the outlet opening **18** disposed concentrically to the central longitudinal axis **36**, and forms the spray jet **20** downstream of the outlet opening **18**, cf. FIG. **1**.

By providing a restrictor downstream of the mixing chamber **30**, which in the embodiment as illustrated is constituted by the perforated plate **38** and the orifice **44** disposed at a distance from the perforated plate **38**, the two-substance nozzle **10** is adapted to allow a jet angle α of the spray cone **20** that is essentially independent of the pressure of the gas supplied and the liquid supplied, cf. FIG. **1**. In any case, the spray nozzle **10** according to the invention permits to achieve an essentially constant jet angle α over a wide range of pressure of the liquid and pressure of the gas. Therein, a restrictor can be constituted merely by means of the perforated plate **38**, if the orifice **44** is omitted.

Typically, the spray angle is essentially constant at a water pressure between 4 bar and 8 bar and an air pressure of 1 bar. With an air pressure of 2 bar, the jet angle varies upon variation of the water pressure between 4 bar and 8 bar only by somewhat less than 10°. However, upon a variation of the water pressure, there is variation of a distribution of the liquid-gas mixture within the spray cone **20**. Indeed, with increasing air pressure, there is more liquid-gas mixture located in the center of the spray cone **20**. While, with increasing water pressure, there is less liquid-gas mixture located in the central zone of the spray cone **20** around the central longitudinal axis **36**. Using the two-substance nozzle **10** according to the invention, aimed control of a liquid distribution and distribution of the liquid-gas mixture within the spray cone **20**, respectively, is feasible.

The illustration of FIG. **10** shows the swirl insert **42** in an oblique front view. The grooves disposed on the outer circumference of the swirl insert **42** and extending obliquely relative to the central longitudinal axis **36** are revealed. On the side facing away from the flow, cf. FIG. **3**, the swirl insert **42** is provided with a stud **62** disposed concentric to the central longitudinal axis. The stud protrudes beyond a bottom of the swirl insert **42**, cf. FIG. **3**. An outer circumference of the stud **62** has a non-circular shape. In the vicinity of the base point of the stud **62** on the swirl insert **42**, the stud is surrounded by a circumferential groove **64**. The groove is formed by driving a plurality of blind holes into the swirl insert **42** parallel to the central longitudinal axis. In the embodiment as illustrated, there are a total of seven blind holes driven into the swirl insert **42** in parallel to the central longitudinal axis **36**. Thus, an outer circumference of the groove **64** is composed of a total of seven segments of circle. The centers of the blind holes are located on a circle that is concentrically surrounding the central longitudinal axis **36**, cf. FIG. **12**. A distribution of the liquid-gas mixture in the spray cone **20** can be controlled via the length of the stud **62**. If the stud **62** is omitted and the surface of the swirl insert **42** facing away from the flow is planar, the spray cone **20** will be in the shape of a hollow cone. Providing the stud **62** causes formation of the spray jet **20** in the shape of a full cone.

The illustrations of FIGS. **11**, **12** and **13** show further views of the swirl insert **42**.

The illustrations of FIGS. **18** through **21** show a swirl insert **70**, modified as compared to the swirl insert **42** of FIG. **10** through **13**, but intended to be employed on the same position in the two-substance nozzle **10** of FIG. **1** according to the invention. The differences to the swirl insert **42** of FIGS. **12** and **13** will be discussed below.

As distinguished from the swirl insert **42**, the swirl insert **70** does not include the groove **64** surrounding the stud **62**. Thus, the stud **62** is disposed on a planar surface **72** of the swirl insert, wherein the surface **72** is located on the downstream side of the swirl insert, in the installed condition of the swirl insert, cf. FIG. **3**. The stud **62** as such has a non-circular shape, as with the swirl insert **42**, the stud circumference being constituted by mutually adjoining concave partial surfaces of a circular cylinder. In total, the circumference of the stud **62** is formed by seven mutually adjoining partial circular cylindrical surfaces. The grooves extending obliquely relative to the flow direction on the circumference of the swirl insert **70** are identical to the grooves on the swirl insert **42**. As with the swirl insert **42**, a total of seven obliquely extending grooves are provided on the outer circumference.

The illustration of FIG. **22** shows a total of four curves to depict the variation of the jet angle of the two-substance nozzle according to the invention in FIG. **1** with varying water pressure. The different curves correspond to different air pressures. The curve denoted by a diamond depicts the variation of the jet angle at an air pressure of 1 bar, the curve denoted by a square the variation of the jet angle at an air pressure of 2 bar, the curve denoted by a triangle the variation of the jet angle at an air pressure of 2.5 bar, and the curve denoted by circles the variation of the jet angle at an air pressure of 3 bar.

It is revealed that upon a variation of the water pressure, the jet angle varies within a comparatively narrow range independent of the air pressure. Thus, the two-substance nozzle according to the invention is not susceptible to variations of the water pressure, as far as the jet angle is concerned.

The illustration of FIG. **23** shows the qualitative variation of the water distribution within the spray jet of the two-substance nozzle according to the invention in FIG. **1** at variable air pressure and water pressure, respectively, in a diagrammatic graph. The reference numerals **74**, **76** and **78** designate different water distributions within the spray jet, and what is revealed is that with increasing air pressure, there is more liquid in the center of the jet. The water distributions **74**, **76** and **78** are in total approximately axially symmetric around the center axis of the spray jet.

As depicted in FIG. **23**, with increasing water pressure, starting from the water distribution **78**, there is at first the water distribution **76** and then the water distribution **74** occurring. With increasing air pressure, there is at first the water distribution **74**, then the water distribution **76**, and finally the water distribution **78** occurring. The lines **80** and **82** designate approximate parting lines between the individual ranges of different water distributions **74**, **76** and **78**, respectively.

Consequently, the two-substance nozzle according to the invention allows adjustment of a desired water distribution by means of an adjustment of the water pressure and/or the air pressure at an essentially constant jet angle. In this manner, long products in a continuous casting unit may be subject to different cooling regimes by varying the water pressure and/or the air pressure of the two-substance nozzle according to the invention.

The invention claimed is:

1. A two-substance nozzle for spraying a liquid-gas mixture, comprising a nozzle housing including at least one liquid inlet leading into a mixing chamber and at least one gas inlet leading into the mixing chamber, a swirl insert, an outlet chamber between the swirl insert and an outlet opening on the downstream end of the outlet chamber, a restrictor on the downstream end of the mixing chamber, and an intermediate chamber between the restrictor and the swirl insert, wherein an outlet channel formed by the outlet opening is shorter than the mixing chamber, as viewed in an outflow direction, and wherein the mixing chamber has a central longitudinal axis, and the at least one liquid inlet leads into the mixing chamber approximately tangentially to an imaginary circle around the central longitudinal axis.

2. The two-substance nozzle according to claim **1**, wherein the restrictor includes a perforated plate.

3. The two-substance nozzle according to claim **2**, wherein the perforated plate has a plurality of through-holes, all of the plurality of through-holes being disposed adjacent a periphery of the perforated plate.

4. The two-substance nozzle according to claim **1**, wherein the restrictor has an orifice including one single, central through-hole.

5. The two-substance nozzle according to claim **1**, wherein the restrictor has at least one perforated plate including a plurality of through-holes disposed adjacent a periphery of the perforated plate and at least one orifice including one single, central through-hole.

6. The two-substance nozzle according to claim **5**, wherein, as viewed in the outflow direction, the perforated plate is located upstream of the orifice.

7. The two-substance nozzle according to claim **6**, wherein, as viewed in the outflow direction, the orifice is spaced from the perforated plate.

8. The two-substance nozzle according to claim **1**, wherein the swirl insert includes a plurality of bores disposed in a peripheral zone of the swirl insert or grooves disposed on an outer circumference of the swirl insert, wherein the bores or grooves extend obliquely or helically relative to a central longitudinal axis of the outlet chamber.

9. The two-substance nozzle according to claim **1**, wherein the swirl insert includes a stud protruding into the outflow direction and located in a central zone on a downstream side of the swirl insert.

10. The two-substance nozzle according to claim **9**, wherein the stud is surrounded by a groove formed in the swirl insert.

11. The two-substance nozzle according to claim **1**, wherein at least two liquid inlets are provided, each leading into the mixing chamber approximately tangentially to the imaginary circle around the central longitudinal axis, but in opposed directions relative to one another.

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